

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE APPLE MAGGOT OR "RAILROAD WORM."

(Rhagoletis [Trypeta] pomonella Walsh.)

By A. L. QUAINANCE,

In Charge of Deciduous Fruit Insect Investigations.

Five important insect pests injure the fruit of the apple in the United States, namely, the codling moth (*Carpocapsa pomonella* L.), the lesser apple worm (*Enarmonia prunivora* Walsh), the plum curculio (*Conotrachelus nemophar* Hbst.), the apple curculio (*Anthonomus quadrigibbus* Say), and the species under consideration.



FIG. 1.—Apple maggot (*Rhagoletis pomonella*): a, Adult; b, larva or maggot; c, funnel of cephalic spiracle; d, puparium; e, portion of apple showing injury by maggots. a, b, and d, Enlarged; c, still more enlarged; e, reduced. (Original.)

The apple maggot, as the name implies, is the larva of a fly or dipterous insect, and belongs to the family Trypetidae, which group contains numerous other fruit-infesting maggots,^a some of them very serious pests, and, from their structure, mode of life, and feeding habits, very difficult of control. Apples injured or "railroaded" by the apple maggot show discolored winding burrows, or tracks, and

^a *Anastrepha (Trypeta) ludens* Loew., the so-called Mexican orange worm, is an enemy of oranges in portions of Mexico, infesting also the guava and mango, and *A. acidusa* Walk. infests the peach in the same country. *Rhagoletis ribicola* Doane infests currants and gooseberries in the United States, as does also *Epochra canadensis* Loew. *R. cingulata* Loew has recently been found to be a cherry pest in this country, working in a way similar to the European cherry fly, *Trypeta cerasi* L. (*signata* Meig.), *Ceratitis capitata* Wied., the so-



cavities here and there in the flesh, and when infested with several larvæ the pulp will be usually quite honeycombed with their burrows and more or less broken down into a yellowish mass, merely held together by the skin. (See fig. 1, *c*.)

DISTRIBUTION AND DESTRUCTIVENESS.

The apple maggot is a native American species, its natural food being haws (*Crataegus*), and in at least one instance it has been bred from crab-apples. Its feeding upon cultivated apples is thus an acquired habit, and although the insect has been reported from widely separated points in the central and eastern States, indicating its possible general distribution, for some reason it does not attack the apple throughout its range, but only in certain localities and portions of the country. This circumstance is a fortunate one for the apple grower, and from a scientific standpoint is of much interest. Walsh thought it might be explained on the supposition of the development in the New England States, where its injuries to apples were first noticed, of a race of apple-infesting individuals, the descendants of which, with the acquired habit, have been gradually distributed to other localities.

The apple maggot was described by Walsh in the *American Journal of Horticulture* for December, 1867, pages 338-343, and also in the First Report of the Acting State Entomologist of Illinois, from flies from eastern apples and from Illinois haws. Adult specimens from this latter fruit had been secured by him some five or six years earlier, and in July, 1867, he reared flies from maggots infesting apples from Connecticut, Massachusetts, and New York, and conclusively showed the identity of the insects infesting haws in Illinois with those infesting apples in the northeastern part of the United States. In the New England States mentioned, however, the species had been noted as an enemy of apple for some years before the time of Walsh's description. By 1866 it was common in the Hudson River country, at North Hempstead, Long Island, in the Oneida community in New York State, at East Falmouth, Mass., and probably in Vermont, and it occurred in Connecticut.^a

called Mediterranean fruit fly, or Bermuda peach maggot, is widely distributed, infesting a considerable variety of soft fruits, as oranges, peaches, plums, pineapples, and bananas, but fortunately has not yet been introduced into the United States. In Europe *Tephritis onopordinis* Fab. injures celery, and *T. tryoni* Froggatt seriously infests, in portions of Australia, bananas, peaches, oranges, etc., and another species of this genus (*psidi* Froggatt) in that country infests guavas. *Trypeta musæ* Froggatt seriously injures bananas in the New Hebrides. Some of these species are very general feeders, and the greatest care should be exercised, especially in the case of the Bermuda peach maggot, that they be not introduced into the United States.

^a First Rept. Acting State Ent. Illinois, pp. 29-33 (1867).

In 1881 the apple maggot was reported by Professor Comstock^a from Ithaca, N. Y., in apples, and was bred by him from *Cratagus* at Washington, D. C. Professor Cook,^b in 1881, received specimens from Delavan, Wis., where it was reported as doing very great injury, and the year following, the insect was the cause of considerable loss in Ingham and adjoining counties in Michigan.

Lintner, in 1885, gives the additional localities of North Ashburnham, Mass., Franklin and Schenectady, N. Y., and Brandon, Vt. Its introduction into Maine, as stated by Professor Harvey,^c occurred prior to 1882, by which time it had become well established, and by 1899 occurred quite generally over the State. Its occurrence at Montclair, N. J., was recorded in 1889 by Mr. E. Williams, in *Garden and Forest*, page 527, and this locality is also given for the apple maggot by Dr. J. B. Smith in his list of insects of New Jersey, page 687 (1899).

In 1894 Doctor Howard^e records the occurrence of the apple maggot from Waynesville, N. C., and Doctor Fletcher^f records its first appearance in Canada, August 31, 1896, in apples from Adolphinstown, Ontario. As stated by Professor Lochhead,^g it had become quite injurious by 1902, more than one-half of the crop having been destroyed in some orchards in Prince Edward County. Professor Osborn,^h on the authority of Professor Hine, records its occurrence in northwestern Ohio in 1904, and states that injured fruit comes on the market at Columbus, though perhaps from outside of the State. Doctor Chittendenⁱ notes that the apple maggot was unusually injurious in Ohio in 1903. By 1905 the insect had extended its range in Canada, as shown by the records of Doctor Fletcher^j of its occurrence at Comò and St. Hilaire, Quebec. The apple maggot is recorded from Minnesota by Professor Washburn,^k and the records of the Bureau of Entomology show the additional localities of Dyberry, Pa., and Douglas, Mich.

Numerous records of this Bureau, as well as published accounts, show that the insect is generally distributed throughout the greater part of the New England States, and that it is a very destructive

^a Rept. Ent. U. S. Dept. Agric., 1881-82, p. 196.

^b Rept. Mich. Hort. Soc., 1881, p. 200.

^c Second Report N. Y. State Ent., p. 121 (1885).

^d Ann. Rept. Maine State Coll. Agr. Exp. Sta., 1889, Pt. III, pp. 196-241. Insect Life, VII, p. 279.

^e Rept. Ent. and Bot. Exp. Farms Canada for 1896, p. 257 (1897).

^f 33rd Ann. Rept. Ent. Soc. Ont., p. 67, 1902 (1903).

^g Bul. 46, Div. Ent. U. S. Dept. Agric., p. 88 (1904).

^h Yearbook, U. S. Dept. Agric. for 1903, p. 563.

ⁱ Rept. Ent. and Bot. Exp. Farms of Canada for 1904, p. 238 (1905).

^k Bul. 93, Minn. Agric. Exp. Sta., p. 118 (1905).

enemy to apples. The flies do not spread rapidly, and hence individual orchards or certain varieties of apples may suffer severely, while those adjoining may be little injured. Although the pest was bred from haws, in 1867, in Illinois, there has been but one record of its infesting apples in that State.^a

FOOD PLANTS.

The natural food of the apple maggot is wild haw (*Crataegus*), and probably several species are infested. It was bred from haws by Walsh in Illinois, by Cook in Illinois and Wisconsin, and by Comstock at Washington, D. C. Despite its supposed general occurrence in the fruit of this plant, no further records of breeding from haws have been found, and Professor Harvey states that it was not found in haws in Maine. During the past three years the Bureau of Entomology has collected or received fruit of *Crataegus* spp. from various parts of the country, but has not observed it to be infested with the apple maggot in any instance, and it appears quite doubtful if the distribution of the species is as general as is that of its native food plants.

The early statements of the probable feeding of this species on crab-apple appear not to have been based on actual observations, and aside from Riley's record of its occurrence on crabs,^b no definite data have been presented to show that it infests this fruit. Professor Harvey thought it improbable that this fruit would be used, for the reason that it is quite green and hard during the period of flight and oviposition of the flies. The insect was found infesting plums and late cherries in northern Michigan, by Professor Cook,^c in 1889, though no additional records of its occurrence in these fruits have been seen.

Of apples, sweet and subacid summer varieties are worst attacked, but fall and winter sorts are also infested, including distinctly acid varieties. Professor Harvey has prepared a list of apples showing their relative degree of infestation as observed by him in Maine during his careful study of the apple maggot.^d

^a Cordley, Orchard and Garden, 1889, p. 192.

^b Am. Agric., 1872, p. 263.

^c Second Ann. Rept. Mich. Agric. Exp. Sta., p. 153.

^d Loc. cit.

*Varieties of apples known to be affected by Rhagoletis (Trypeta) pomonella.**

Variety.	Flavor.			Time of maturity	Remarks
	Sweet	Sub acid.	Acid		
Alexander			+	Autumn	Sparsingly infested.
Bullock (Am. Golden Russet)				Winter	Do.
Bulley Sweet	+			do	Do.
Baldwin				do	Do.
Benoni		+		Autumn	Badly infested.
Bough				Summer	Do.
Canaan Baldwin				Winter	Sparsingly infested.
Catshead		+		Autumn	Do.
Chenango		+		do	Badly infested.
Colvert		+		do	Sparsingly infested.
Danvers				Winter	Do.
Dayton				do	Do.
Dorby Pippin				do	Do.
Elana		+		Autumn	Do.
Early Harvest		+			Badly infested.
Esopus (Esopus Spitzenburg)		+		Winter	Do.
Fall Jonneting		+		Autumn	Do.
Fall Pippin		+		do	Sparsingly infested.
Fameuse		+		Winter	Do.
Franklin Sweet	+			Autumn	Badly infested.
Garden Roynd		+		do	Do.
Golden Ball		+		Winter	Sparsingly infested.
Golden Russet				do	Do.
Gravenstein				do	Badly infested.
Grimes				do	Sparsingly infested.
Hightop Sweet	+			Autumn	Badly infested.
Hubbardston		+		Winter	Sparsingly infested.
Huribut		+		Autumn	Badly infested.
Irish Peach		+		do	Sparsingly infested.
Jewett Red		+		Winter	Badly infested.
King Sweet				Summer	Do.
Lady Sweet	+			Winter	Sparsingly infested.
Malden Blush				Autumn	Do.
Mexico	+			do	Do.
Mother				Winter	Badly infested.
Munson				Summer	Do.
New York Sweet				do	Do.
Northern Spy				Winter	Do.
Oldenburg (Duchess)			+	Autumn	Sparsingly infested.
Paradise Sweet				Winter	Badly infested.
Peckham (?)		+		do	Do.
Pewaukee (?)		+		do	Sparsingly infested.
Porter				Autumn	Badly infested.
Pound Sweet	+			Winter	Sparsingly infested.
Primate				Summer	Do.
Pumpkin Sweet				Autumn	Badly infested.
Ramsdell				Winter	Sparsingly infested.
Red Astrachan		+		Summer	Badly infested.
Rhode Island Greening				Winter	Sparsingly infested.
Ribston				do	Do.
Rolle		+		do	Do.
Russell		+			Badly infested.
Snow				Autumn	Do.
Somerset		+		do	Sparsingly infested.
Sops of Wine		+		Summer	Badly infested.
Tetofski	+			do	Do.
Tolman				Winter	Do.
Tompkins King	+			do	Sparsingly infested.
Twenty Ounce		+		Autumn	
Wagener		+		Winter	
Wealthy				do	Badly infested.
Westfield (Seek-no-further)		+		do	
Williams		+		Summer	Do.
Winthrop Greening			+	Autumn	Do.
Yellow Bellflower		+		Winter	Do.

*Names of varieties of apples have been corrected to agree with those given in "Nomenclature of the Apple," by W. H. Ragan. Bul. 56, Bur. Plant Industry, U. S. Dept. Agric. (1905).

The susceptibility to injury of the respective varieties mentioned, as observed in Maine, would not necessarily be true for other regions, but the list will serve to show that all classes of fruit are subject to

attack. As a general statement, it may be said that the insect will be most destructive to summer and fall varieties, or to those varieties which are ripe or are approaching maturity during the period of principal activity of the flies.

HOW THE INSECT SPREADS.

It is not known whether the apple maggot has spread from the New England States, where its injuries were first noticed, to the several localities where its presence has been observed—as in Ohio, Wisconsin, Michigan, North Carolina, etc.—or whether the insect, already present on haws, simply turned its attention to apples. The former view, however, appears the more probable, and its spread would have been readily brought about by the introduction of infested apples. In regions where the insect occurs in apples, a considerable amount of infested fruit will be barreled, the larvæ later deserting the fruit and forming puparia on the bottom of the barrel. In the ordinary course of commerce the insect would thus be introduced into new localities, often quite remote. In view of the extent of apple production in the territory which has long been infested with this species (i. e., the New England States), and the consequent almost certain dissemination of the apple maggot to various parts of the country, it is cause for much surprise that the insect is not much more generally and widely established as an apple pest. It is very probable that the insect has been introduced into most of the apple-growing regions in the United States and also into those of Europe and the Colonies, but for some reason has not established itself. Thus the insect has been frequently found in apples on the markets in Washington, D. C., though there is no evidence to indicate that it has become established in orchards in that vicinity.

When once established in an orchard, its spread fortunately is usually very slow. It may confine its attack to a single tree, for two or three years, before spreading to adjacent trees of the same or other varieties equally subject to attack; and varieties seriously infested in one orchard may be exempt in another. The slowness of its spread from tree to tree and from one orchard to another has been commented upon by numerous workers.

The flies in their habits are exceedingly local, apparently confining their attention to the trees upon which the previous generation developed—in marked distinction to the spreading habits of many other insects. This habit is a very fortunate one for the fruit grower, and is of much practical importance in control, permitting great reduction and possible extermination of the pests when infestation is limited to but a few trees, and especially in localities but recently invaded.

DESCRIPTION.

Egg.—The eggs of the apple maggot are quite small, varying from 0.8 to 0.9 mm. in length by 0.2 to 0.25 mm. in width, fusiform, and light yellow in color as taken from the fruit. A short, broad pedicel, about one-twentieth the length of the egg, is found at the broader end, which end is darker and pitted with irregular hexagonal cells with raised lacerated borders for about one-fourth the length of the egg. (See fig. 2, *a*.)

Larva.—The larva (fig. 1, *b*) is footless, and when full grown is from 7 to 8 mm. long, with a width of from 1.75 to 2 mm., yellowish-

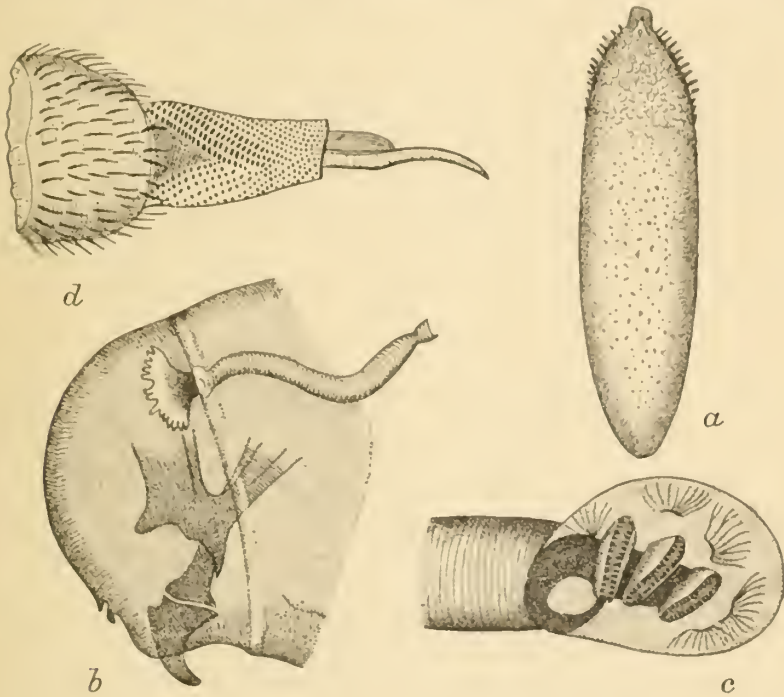


FIG. 2.—*Rhagoletis pomonella*. *a*, Egg; *b*, head of larva, showing chitinous hooks and framework within the head, and funnel-shaped spiracle; *c*, caudal spiracle; *d*, ovipositor, with which eggs are placed beneath skin of apple. All greatly enlarged. (*b*, *c*, After Comstock; *a*, *d*, after Harvey.)

white in color, at times tinged with greenish. The body is composed of 14 segments, widest across the ninth, tenth, and eleventh, and sloping gradually backward, and more rapidly toward the head end. The caudal end is truncate, and on the lower portion of the anterior end (first segment) is a pair of black, curved, parallel hooks, attached to a chitinous framework within the head, the hooks being used to rasp the pulp in the liberation of juice for food. A pair of spiracles occurs on the dorsal surface on each side at the juncture of the first

and second segments (fig. 2, *b*) and a pair on the sloping surface of the caudal segment. The spiracles on the cephalic end have funnel-shaped mouths, the funnel being bordered with a double row of about 20 projections. The caudal spiracles each show 3 transverse slit-like openings and 4 groups of bristles. (See fig. 2, *c*.)

Pupa.—The pupa is a small, barrel-shaped structure, pale yellowish-brown in color, measuring about 4.2 to 5.2 mm. in length, with a width of from 2 to 2.6 mm. The larva in pupating does not shed its skin, but simply contracts, assuming an oval form, causing the cephalic spiracles to project in front as tubercles. Although the caudal end also shrinks, the spiracles are still visible, as are also the body segments of the larva. The true pupa is formed within the larval skin. (See fig. 1, *d*.)

Adult.—The parent of the apple maggot is a two-winged fly (fig. 1, *a*), somewhat smaller than the house fly, of a general black color, with yellowish head and legs, greenish eyes, and dark feet. In the male there are 3, and in the female 4 white bands across the abdomen. Across the wings of both sexes are 4 black bands as shown in the figure. The females are from 5 to 6 mm. in length, with a spread of wings of about 12.15 mm. The males are somewhat smaller.

LIFE HISTORY AND HABITS.^a

There is but one generation of the apple maggot each year, though the occurrence of maggots in the fruit during the summer and autumn, due to the great irregularity in time of appearance of the flies, is calculated to mislead those not familiar with the insect's life history. The time and appearance of the adults is thought to be influenced by the date of the ripening of the fruit which they infested the previous season, though this supposition has not been established. During an ordinary season in Maine, the flies will begin to appear and will be ovipositing about July 1, and earlier in the States to the south. By the middle of July, in Rhode Island, during an average season, as stated by Profs. F. W. Card and A. E. Stene, early varieties subject to attack will show many of the egg punctures of the females.

Flies have lived in confinement for three weeks, and out of doors the period is doubtless somewhat longer. The female makes punctures through the skin of the apple by means of her sharp ovipositor (fig. 2, *d*), inserting the eggs singly into the flesh in a vertical position. Oviposition may occur on any part of the fruit, though mostly on the side and especially on the paler portions, where the apple has

^a The apple maggot was carefully investigated in Maine by the late Professor Harvey, and his Report (l. c.) has been largely the basis of the present article.

been protected from the sun by the foliage. An individual female is capable of producing from 300 to 400 eggs, egg laying continuing throughout her life. About one-half minute is occupied in the act of depositing a single egg, and the characteristic brownish speck left by the ovipositor can, upon close examination, be detected by the unaided eye, and resembles the brownish rusty spots occurring normally on some varieties. These egg punctures may be best observed, however, with a hand lens, and are then seen to be oblong or circular holes, with the surrounding border brownish and somewhat shrunken. In four or five days, under favorable conditions, the egg hatches and the minute footless maggot begins to feed on the pulp of the fruit. Although the larva is without true opposable jaws, it is provided with two hooks on the head above the mouth by which the pulp is rasped loose, the larva drawing into the mouth the juices thus liberated. The pulp which is not eaten soon turns brown and renders the burrows through the flesh more readily visible. The larva, in its feeding, channels here and there through the flesh, sometimes burrowing for a distance just under the skin, the brownish trail in light-skinned varieties appearing as a linear bruise.

The rate of development of the larvæ conforms to that of the fruit, and the larvæ do not mature until the fruit is ripe. Early appearing flies attack the summer varieties, and those appearing later infest fall and winter sorts. Their development is checked by cold, and they are apparently able to exist for a considerable time in a practically stationary condition until the maturity of the fruit permits of their further growth to maturity.

Apples at gathering time may show no exterior indications of infestation, yet when cut open will be found thoroughly burrowed and honeycombed by the larvæ; or the apparently sound mature fruit may be so infested with the small, inconspicuous larvæ and eggs that it may be soon destroyed after storing. The work of a single maggot will injure the value of the fruit, though a dozen or more may often be present. Under favorable conditions of temperature and in ripening fruit, the maggots will become full grown in four or five weeks. The larvæ mature as the fruit is ripe, and leave this after it has fallen to the ground, as no exit holes have been noticed in fruit on the trees. In deserting the fruit a hole is made through the skin and the larva burrows an inch or less below the surface of the soil, or on sod land probably pupates around the roots of the grass; or sometimes the pupal stage is entered on the surface of the ground under the decayed fruit. In fruit in barrels, in storehouses, etc., the larvæ pupate on the bottom of the receptacle, and the puparia are often very numerous in such places. The insect remains in the pupal stage

until the following summer, the adult fly appearing early or late, depending apparently on whether the larvæ infested summer, fall, or winter fruit.

INSECTS WHICH MAY BE MISTAKEN FOR THE APPLE MAGGOT.

There will often be found in apples partly or wholly decayed, as from the work of the apple maggot or other causes, larvæ which might very readily be mistaken for those of the species under consideration. Principally the larvæ of two kinds of flies will thus be found, namely, the vine-loving pomace fly (*Drosophila ampelophila* Loew)—a small clear-winged, red-eyed fly—and the pretty pomace fly (*Drosophila amona* Loew), similar to the former, but with black spots on the wings. These insects are of interest as likely to be mistaken for the apple maggot and hence the cause of needless alarm. They are of little economic importance, though undoubtedly hastening the decay of fruits.

PREVENTIVE MEASURES.

The apple maggot has proved to be an unusually troublesome insect to combat successfully. The eggs are deposited beneath the skin of the fruit, within which also the larva feeds until full grown. The pupal stage is passed just under the soil, or around the roots of grass in sod land, and the flies do not feed in a way to permit of their destruction. Spraying with arsenicals, so effective against the codling moth or apple worm, is for this pest quite useless.

The insect, however, may be attacked in two important ways. As stated, the larvæ do not leave the fruit until the latter has ripened and fallen to the ground. The prompt gathering and destruction of the windfalls, before they are deserted by the maggots, would serve to keep the insects greatly reduced, amounting to practical extermination if thoroughly carried out. This practice has long been recommended by entomologists, and comprises the most effective measure of controlling the pest at present known. Greatest benefit will come from the practice when carried out uniformly by the orchardists of a community. Allowing the wormy fruit to decay on the ground is most favorable to multiplication of the apple maggot. Orchardists having this pest to contend with should arrange to destroy the infested fruit promptly after it falls, and this may be accomplished in whatever way is most practicable under individual conditions.

Picking up the fruit by hand will often prove feasible and can be done by children, but great care is necessary that the work be done thoroughly. The gatherings should be made daily if possible, or at least every two or three days. The fruit may be fed to stock, taking

care that any excess not at the moment needed be stored in tight boxes or receptacles so that any larvæ deserting the fruit will be forced to pupate on the bottom of the container, where later they may be destroyed. When the drop fruit is not needed for the stock, it may be simply thrown into a hole or holes here and there in the orchard, to be finally covered with 2 or 3 feet of earth in the late fall after frosts have occurred, to prevent the escape of flies the following season. The work of gathering need not be begun until the first ripe windfalls of the early varieties are found, but should be kept up from this time until all the fruit has been harvested.

Orchards may often be pastured with sheep, hogs, or cattle, in a way to insure the destruction of the windfalls, and this practice is recommended as the cheapest and most satisfactory method of dealing with the apple-maggot problem. Orchards may be permanently pastured or the stock turned in daily in sufficient numbers and at times to accomplish the desired consumption of the fallen fruit. This practice will be especially useful in commercial orchards, and, where infestation from adjacent orchards is not great, will insure practically clean fruit.

Plowing and cultivation of orchards would appear to be a useful practice in the control of this pest, and these methods have been more or less recommended for some years. Careful experiments in Rhode Island on the value of such work have recently been reported by Professors Card and Stene.^a Puparia of apple maggots were placed at different depths in the soil, ranging from 1 to 6 inches, to approximate conditions resulting from plowing to bury the pupæ, but this was found to have little effect in preventing the escape of flies, and the conclusion was reached that spring plowing of orchards to turn under the pupæ was valueless, under the soil conditions which there obtained.

It is thought, however, that frequent tillage of the orchard in early summer may be unfavorable to the development of the pupæ to flies, and experiments made in 1904 by Messrs. Card and M. A. Blake^b with pupæ placed in boxes in which the soil was frequently stirred, resulted apparently in their complete destruction. More extended and conclusive experiments along these lines are urgently needed. Aside from its possible value in destroying the apple maggot, frequent tillage of orchards in late spring and early summer is desirable, especially for young trees, as favoring a better tree and fruit development.

^a Seventeenth Ann. Rept. R. I. Agr. Exp. Sta., Part II, p. 191 (1904).

^b Eighteenth Ann. Rept. R. I. Agr. Exp. Sta., Part II, p. 197 (1905).



Much infested fruit goes to market, or is stored at home for future consumption. The refuse from such fruit should always be destroyed, and the barrels and boxes in which the maggots have pupated upon leaving the fruit should be treated in such a way as to insure the destruction of the pupæ. The floor of storerooms should also be carefully swept, and the sweepings collected and burned.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *March 27, 1908.*

[Cir. 101]

○